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Technical Report 721

Evaluating the Benefits and Costs of the Enlisted Personnel Allocation System (EPAS)

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The Army Research Institute, with the assistance of the General Research Corporation, is undertaking a project to modernize and improve the way the Army determines the Military Occupational Specialty (MOS) for which an individual should be trained. This project is called the Development of the Enlisted Personnel Allocation System (EPAS).

A key task in the EPAS development is the performance of a benefit-cost analysis of the prototype system that will provide important (Continued)

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information on the potential benefits of improving accession management and training seat allocation.

To support the benefit-cost analysis, a series of simulations were run which demonstrated the capability of EPAS to operate feasibly under realistic scenarios. Further, EPAS is likely to produce substantial improvements over present soldier allocation procedures.

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Evaluating the Benefits and Costs of the Enlisted Personnel Allocation System (EPAS)

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FOREWORD

The Army Research Institute for the Behavioral and Social Sciences (ARI) is undertaking a comprehensive research program to improve the selection, classification, and allocation of Army personnel. A key part of this program is the Enlisted Personnel Allocation System (EPAS), which will improve personnel performance by achieving a better match between Army requirements and the capabilities of the people applying for service. This report presents the benefit-cost analysis supporting the development and implementation of EPAS.

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EVALUATING THE BENEFITS AND COSTS OF THE ENLISTED PERSONNEL ALLOCATION SYSTEM (EPAS)

EXECUTIVE SUMMARY

Requirement:

The Army's need to improve the way new accessions are assigned to Military Occupational Specialties (MOS) led to the development of the prototype Enlisted Personnel Allocation System (EPAS). This report presents the benefit-cost data supporting an EPAS.

Procedure:

A set of five simulations of the allocations EPAS would recommend were run. The scenarios represented

1. conditions similar to those in FY 84
2. fewer quality applicants
3. a three-fold increase in summer training requirements over those in the three previous quarters
4. simulated applicants not accepting the first recommended assignment
5. not using the look-ahead function of the EPAS optimization

Using predicted attrition as a comparison of EPAS assignments to the actual assignments in FY 84, we computed the cost savings that could have resulted had EPAS been used.

Findings:

The simulations show that EPAS could save over $25M each year in attrition costs alone. Further, EPAS's performance in the test scenarios demonstrated that it was sufficiently robust to support policy analyses.

Utilization of Findings:

The EPAS design was been demonstrated to be a cost-effective system. These findings indicate that a field test of EPAS should proceed.

EVALUATING THE BENEFITS AND COSTS OF THE ENLISTED PERSONNEL ALLOCATION SYSTEM (EPAS)

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I. INTRODUCTION

The Army Research Institute, with the assistance of the General Research Corporation, is undertaking a project to modernize and improve the way the Army determines for which Military Occupational Specialty (MOS) an individual should be trained. This project is called the Development of the Enlisted Personnel Allocation System (EPAS).

A key task in the EPAS development is the performance of a benefit-cost analysis of the prototype system. This analysis will provide important information on the potential benefits of improving accession management and training seat allocation.

A series of simulations were run to support the benefit-cost analysis. These simulations demonstrate the capability of EPAS to operate feasibly under realistic scenarios. Analysis of the results of this task will identify whether EPAS warrants implementation as presently envisioned, what kinds of modifications may be necessary, and how final testing and implementation should proceed.

Following this introduction, Section 2 describes the accession process and the role of EPAS in managing that process. Section 3 then discusses the benefit-cost criteria and the EPAS computer simulations that will be used to test the robustness of the results. Section 4 presents the results of the simulations and Section 5 gives our estimates of EPAS costs.

II. BACKGROUND

ARMY ACCESSION PROCESS

The U.S. Army recruits and trains more people each year than any other organization in this country. Over 300,000 people apply for 130,000 entry-level positions in over 250 different military occupational specialities (MOS). Figure 1 illustrates the major steps an applicant goes through in the enlistment process. The applicant first takes the Armed Services Vocational Aptitude Battery (ASVAB) to determine if he is mentally qualified to enter the Army. The ASVAB includes subtests forming the Armed Forces Qualification Test (AFQT), which determines enlistment eligibility, and other tests for qualifying in nine groups of jobs.

ASVAB scores play a major role in determining who is eligible to enlist and what kind of skill training one can receive. The Army particularly desires high school graduates whose AFQT scores place them in the top half of the general population. These are called quality applicants. The Army is prohibited by Congress from accepting applicants from the bottom 10 percent of the population, and has administratively decided against accepting those in the lowest quartile.

The aptitude testing is followed by a physical examination. After satisfying the mental, physical, and moral standards, the applicant is offered a job assignment by an Army guidance counselor and signs an enlistment contract. He then returns home until it is time to report for active duty (up to 12 months in the future). This delay, between contract signing and reporting for active duty, is permitted by the Delayed Entry Program (DEP).

ARMY PERSONNEL ACCESSION FLOW

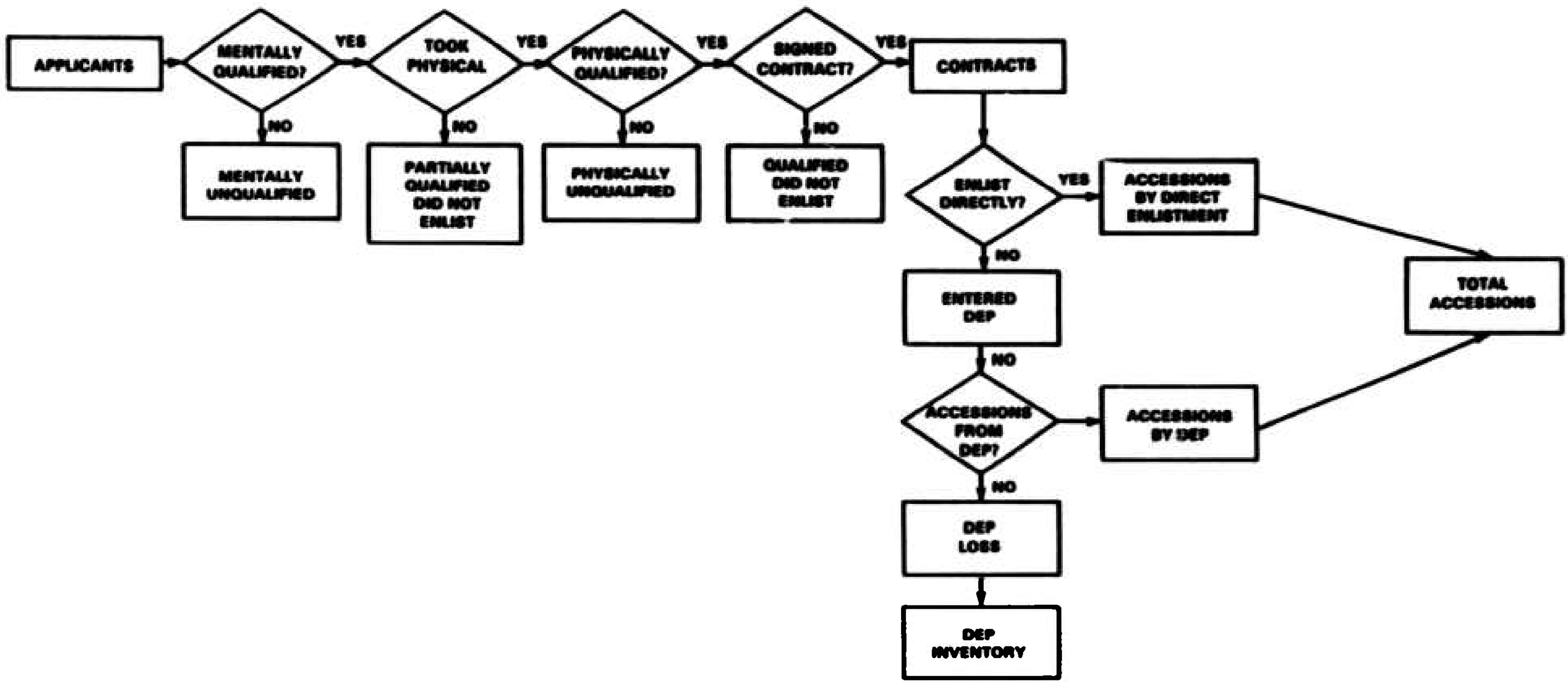

Figure 1. Army Personnel Accession Flow.

Signing the enlistment contract is a key decision point in an applicant's Army career. When they sign their contract, all applicants are guaranteed the kind of training they will receive, even though it may be over a year before they actually receive their training.

While the guarantee of specific job training is a useful recruiting incentive for the Army, the classification process must be managed carefully to meet the following requirements:

- Fill yearly job requirements.
- Ensure applicants meet MOS qualifications.
- Fill near-term and critical training seats.
- Distribute quality personnel into vital jobs.

The present Army person-job match system has been successfully filling all open job requirements. While it permits a satisfactory match of applicants to jobs, its planning capabilities are very limited:

- It cannot "look ahead" and match the projected applicant supply to the remaining job openings.
- It cannot take corrective action to avoid problems or estimate how policy changes will affect the future supply and distribution of personnel.
- It cannot make trade-offs between other important objectives such as minimizing attrition and maximizing job performance.

THE EPAS APPROACH

EPAS uses an optimization approach to allocate applicants to MOS training seats. The general structure of the problem is to:

- MAXIMIZE TOTAL PERFORMANCE
    - SUBJECT TO:
        - Manpower requirements
        - Personnel supply
        - Organizational constraints

Maximizing total performance requires two important assumptions. First of all, it is assumed individuals differ in their performance levels. If all "qualified" individuals cannot be distinguished as to their performance or costs, then there would be nothing to optimize. Clearly, there is substantial evidence that individuals do differ in terms of their performance. (See Soldier Quality Task Force 1985, for example.)

Second, it is assumed that total Army performance can be maximized by summing up individual performance. What the Army is ultimately after are <u>units</u> that perform well. However, modeling and evaluating the interactions of individuals within units is beyond the scope of this project, cannot be supported by current knowledge about group performance, and is not addressed by current training management procedures. Therefore, it appears reasonable to assume that an Army comprised of individuals who perform better (in the aggregate) is preferred over one that doesn't perform as well.

Total performance is presently comprised of two major parts: personnel costs and individual job performance. No doubt other combinations of performance factors will be developed in the near future; this is entirely consistent with the design and flexibility of EPAS. The structure of EPAS is largely determined by the Army's personnel management system.

EPAS uses a two-stage optimization system. The first stage solves the aggregate planning problem of bringing manpower requirements and personnel supply into balance over time. The second stage recommends individual training seats to applicants based upon overall guidance and specific individual attributes.

The optimization approach guarantees that the "best" solution to the management problem will be found. This approach not only provides a solution, but provides information on the value of the best solution, and benefits and costs of resources and policies that affect the problem. Also, the optimization framework facilitates changing the problem and resolving it. These are all very desirable features for such an important decision as accession management and training seat assignment. Nearly $2 billion in resources are involved in this decision. Even more importantly, the readiness and performance of the Army could be substantially improved by better personnel allocation.

Optimization is widely used in industrial and military applications to allocate scarce resources to attain a least cost or highest value course of action. Applications in Army manpower support include the MILPERCEN system which assigns recruits to their first unit and ODCSPER's ELIM-COMPLIP which was honored by a society of management professionals for its use of optimization in manpower planning (Holz and Wroth, 1980). In these applications the many thousands of alternatives, conflicting requirements, and process interactions have mandated using large-scale optimization.

Optimization techniques will significantly help the Army manage recruit classifications and school assignments. Here, the scarce resources are quality applicants. They, along with AFQT Category IIIB-IV applicants, must be assigned an MOS so that the resulting person-job match provides the best MOS-specific performance attainable from the limited supply of quality applicants.

EPAS CAPABILITIES

EPAS uses optimization to improve applicant classification. It encompasses a series of integrated modules that perform forecasting, optimization, and decision analysis for personnel allocation. It will let Army personnel planners evaluate recruiting plans and policies, as well as recommend specific training assignments for applicants. Over a year period, it plans an optimum match of groups of applicants to MOS training seats. This allocation of applicants incorporates:

- A time-sensitive training plan
- MOS quality requirements
- Gender restrictions
- Applicant availability and propensity to accept different DEP periods
- MOS priorities.

The optimization will be updated frequently with current data on school openings and applicant availability.

EPAS Applicant Classification Support

Each week the EPAS optimization will create an ordered list of recommended MOS school seat assignments for each supply group. These supply groups are differentiated by AFQT scores, aptitude area scores, education, and gender. The ordered lists will be input to REQUEST so that day-to-day sequential classifications can incorporate the "look ahead" guidance of the optimizations. This link to REQUEST will overcome the limitations of sequential classification and:

- Make applicant classifications and school assignments consistent with optimal allocation of the scarce high quality applicants.
- Fence attractive MOS for quality applicants.
- Allocate other applicants to MOS based on forecasted market conditions for quality applicants.
- Allocate applicants to make efficient use of their aptitudes.
- Recommend DEP lengths to best cover slack recruiting months.

EPAS Recruiting Management Support

Headquarters, US Army Recruiting Command (USAREC) will use EPAS to assess its options for meeting training classes and quality goals under various recruiting scenarios. USAREC can evaluate DEP policies that are specific to MOS and applicant quality, as well as evaluate the impact on predicted performance of alternative person-job matches. It is particularly useful for evaluating complex and often competing job requirements for quality and high school graduate applicants.

Starting at any point in a fiscal year, EPAS can run a day-to-day simulation of recruit classification. A past year's or a hypothetical series of recruit records can be processed to meet a given training plan; and, policies such as DEP lengths, MOS priorities, and class fill rates can be varied throughout the simulation.

PROCESS DESCRIPTION

EPAS may be operated in either the Classification Mode, which supports the actual classification of applicants to jobs; or the Planning Mode, which supports recruiting management. The information flow between the EPAS modules that support these modes is depicted in Figure 2.

Classification Mode

This mode provides real time support to the guidance counselors' applicant classification decisions. Because it uses optimization, it can make better recommendations than the current classification system, the REQUEST MOS Match Module (M^3). As does M^3, it also uses the existing reservation and other management support of the REQUEST system. The following paragraphs describe the functional flow of the EPAS Classification Mode.

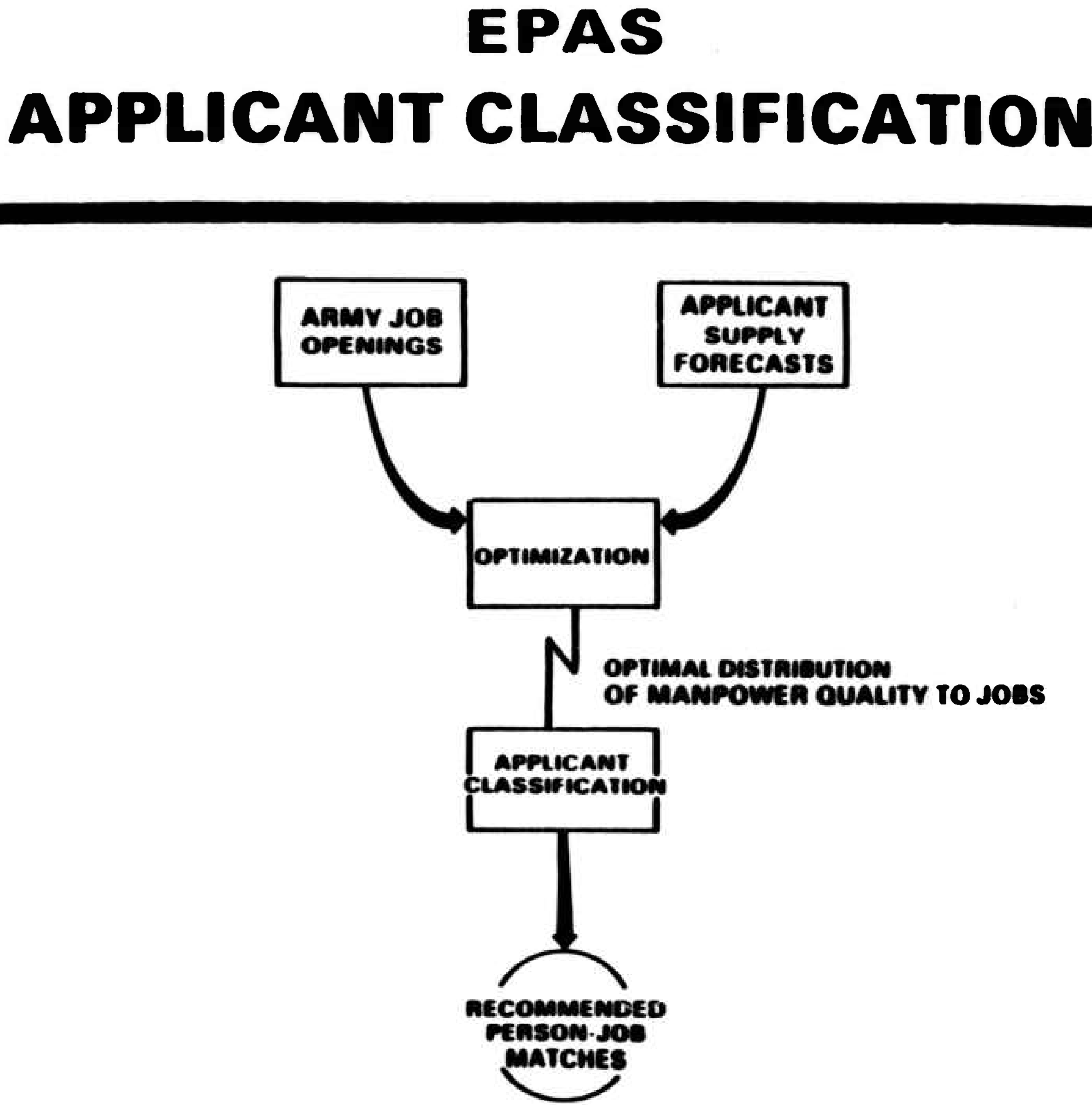

Figure 2. EPAS Applicant Classification.

Applicant Forecasts. EPAS can generate alternative forecasts by educational level and AFQT score. The Classification Mode will use forecasts that correspond to the USAREC mission statements.

MOS Requirements. The Classification Mode uses the training requirements from the REQUEST system. (In the long run, reduced turnover due to EPAS could alter training requirements.)

Optimization. This is the key to EPAS' capabilities. Its inputs are the MOS training requirements and the number of forecasted applicants. Using a structure that incorporates important recruiting policies, the optimization develops an ordered list of recommended job assignments for the different types (gender, education, quality) of applicants forecasted for the next week. Because the optimization can "look ahead" at both the unfilled job requirements and the forecasted time-phased applicant supply, its ordered lists impart an "artificial intelligence" to classification recommendations. This allows it to recommend job assignments which meet Army goals while considering trade-offs among applicant quality, availability, and timing of accessions.

Ordered Lists of Recommended Jobs. The optimization solution would represent only one of many possible sets of individual job assignments. Factors such as individual qualifications, interests, and the short-term availability of jobs preclude many applicants from accepting this solution. Therefore the optimization creates ordered lists of recommended assignments for different applicant groups. Thus if the optimal recommendation is not chosen, alternative feasible recommendations are made in order of their desirability.

Applicant Classification. This module directly supports the guidance counselors. It operates much like the current M^3 in that it recommends job assignments and training start dates as each applicant appears for classification. It differs significantly in that it incorporates the ordered lists from the optimization in its classification recommendations. These ordered lists then provide "look ahead" intelligence for the guidance counselors' day-to-day classification recommendations.

Planning Mode

The Planning Mode uses the basic structure of the Classification Mode to support USAREC's and ODCSPER's accession planning. However, rather than providing classification for individuals, planners can evaluate the allocation recommendations from the optimization or conduct a detailed classification of a hypothetical group of applicants. It permits flexible data input so that alternative policies and applicant availability scenarios can be evaluated.

Applicant Forecasts. In the Planning Mode applicant forecasts can be varied to explore the effects of alternative policies or econometric scenarios. Several econometric forecasting techniques are available or monthly forecasts can be input directly.

MOS Requirements. In like manner MOS requirements can be varied to evaluate different training plans.

Optimization. The applicant allocation strategy from the optimization's solution is one method to assess policy options in the Planning Mode. Evaluating alternatives is easy, since the optimization only takes several minutes to run. However, the allocation plan is general, as it deals with groups of applicants and categories of jobs. More specific information can be provided by classification simulations.

Applicant Classification. EPAS can simulate assigning hypothetical applicants to jobs by processing a stream of simulated applicants. The applicant stream can be similar to some previous year or can be given characteristics (those important to job classification) that are based on estimates of future applicant supply. The Applicant Classification Module processes this stream much the same as it would actual applicants. It can incorporate probabilistic applicant behavior such as incentives acceptance as well as balking at unpopular jobs or electing not to join at all. As the Applicant Classification Module has a number of "policy switches" to set goals for job fill, quality, education, female representation, predicted performance, etc., the simulation can assess the effects of changing these "switches" prior to implementation.

III. APPROACH

A key task in the EPAS development process is the benefit-cost analysis. The objective of this analysis is to:

- Determine whether the improvements generated by EPAS warrant full development.
- Identify the design configuration that appears to be most efficient.

An assumption of this analysis is that some of the benefits to be derived from EPAS are quantifiable and will result in some level of cost savings or cost avoidance. An example would be the potential to reduce first term attrition by improving person-job matches. Other measures of effectiveness will be more more difficult to calculate in dollar terms but may be quantifiable. Finally there will be benefits, due to improved management, that cannot be readily quantified, but may be identifiable by system users.

This section of the report describes the approach proposed for the benefit-cost analysis. The first part identifies the Army functional area where EPAS could have an impact. The second part establishes the criteria for benefit and cost measures. The third part discusses the specific scenarios that will be evaluated to explore different configurations and test the sensitivity of EPAS to various operating environment assumptions. The final part discusses how the benefit-cost criteria will be operationally measured.

CONCERNS

The Army categorizes its manpower management process into the following functional areas:

- Acquire
- Train
- Distribute
- Deploy
- Sustain
- Develop
- Separate

EPAS should have some beneficial impact in all these areas. However, the major benefits of EPAS should occur in the acquire and train functions.

A key concern is the Army's ability to classify applicants into the jobs where they will best perform. Improved performance measures is the subject of a major Army selection and classification measure development effort. Eaton (1983) described this effort, while Schmitz and Nelson (1982) showed that "better" job assignments can increase overall Army performance.

Improved management of recruiting programs was addressed in GAO reports 83-17 and 82-70. Army recruiting management is especially challenging because of the broad spectrum of applicant characteristics. Some applicants have a high aptitude for all jobs, while others qualify in only a few MOS. Another layer of complexity is created because the Army is required to take some applicants who did not graduate from high school. Considering the time-phased availability of the different types of applicants and the job training classes, recruiting management is exceptionally challenging. As discussed earlier, management must necessarily focus on short term, high priority jobs. There is considerable concern about the effects this crisis management approach has on overall classifications.

GAO 82-70 also expressed concern about the Army's ability to select individuals with a high probability of retention. It must be noted, however, that many of the soldiers who tend to stay in the Army have demographic characteristics (less education and lower aptitude scores) similar to those who are the least desirable accessions. This creates a difficult trade off between performance and retention.

GAO 82-70 also recommended that the Army develop the sophisticated information systems that could better profile people in terms of biographical, attitudinal, and aptitudinal data.

Train

Increased training efficiency is a continuing Army concern. One way to increase efficiency is to reduce training losses. Nelson and Schmitz (1985) show that improved allocation of high school graduate males can reduce attrition during the first 2 years of enlistees' service by two percent. Thus, there is a potential for a reduction in training losses in excess of 2,000 soldiers per year.

IDENTIFYING THE BENEFITS AND COSTS OF EPAS

The identification of the benefits from improved personnel allocation is the key research task in performing the benefit-cost analysis. Indeed, this activity is key to not only EPAS, but also ARI Project A: Develop and Validate Improved Selection and Classification Instruments and Standards. Without objective information that such selection, classification, and allocation work can realistically expect to improve personnel decisions it would be folly to continue development efforts. Conversely, quantitative evidence of substantial benefits from improved allocation would provide a strong impetus towards implementing such improvements.

Potential benefits, such as the following, could be considered to assess personnel allocation effectiveness:

- Improved soldier performance
- Reduced personnel costs
- Reduced recruiting costs
- Reduced operating costs
- Improved personnel management

Soldier performance is perhaps the most important aspect of personnel decision making. The Soldier Quality Task Force (1985) attempted to determine the benefits of having better performing soldiers. Incentives such as enlistment bonuses, the Army College Fund, and two year enlistments are justified on the basis of the need for improving soldier performance, especially in critical MOS.

Reduced personnel costs are another important concern for allocation. About one-third of all accessions attrit before completing their enlistment term, and most of this attrition occurs during the first year of service. Attrition is costly, since the Army typically invests at least $8,800 in training each soldier. (See Appendix A.)

Reduced recruiting costs could also be a significant factor in improved personnel management. The average variable personnel acquisition costs tend to be about $3,750 (see Appendix A), and the marginal costs for a high quality accession may exceed $8,000 (Armor 1982). Recruits have often stated that the kind of training offered was a primary reason for enlisting. Thus EPAS could have the potential for increasing the ability of the Army to enlist high quality candidates by assuring an adequate supply of desirable training slots.

The operating cost of the assignment system is also a consideration in the evaluation of EPAS. Significant reductions in these costs would provide a compelling argument for implementation of the system; however, substantial operating cost increases could eliminate EPAS from consideration. Therefore, cost estimates for supporting the EPAS computer system need to be included in the analysis.

Improving the management of soldier accessions is a key part of EPAS. It is designed explicitly to assist ODCSPER and USAREC in terms of achieving recruiting missions, MOS distribution, class size goals, quality objectives, and DEP policies. Additionally, EPAS is set up to evaluate the feasibility or cost of achieving alternative recruiting missions, quality goals, training schedules, and other major accession management issues. EPAS should demonstrate a capability to deal with such kinds of management information.

SIMULATION SCENARIOS

The benefits and costs of EPAS were estimated through a series of simulations. The purpose of these simulations is to:

- Demonstrate the value of EPAS.
- Identify the most efficient configuration of modules.
- Evaluate the sensitivity and flexibility of the system to operate under different scenarios.

The benefit-cost analysis task was performed on the prototype system. Evaluation of this report will determine whether the prototype warrants full field testing with planned implementation. This analysis is not intended to estimate precisely the net benefits of the implemented EPAS. Rather it is to assess whether the prototype is likely to generate substantial improvements, which measures are most likely to be affected by EPAS, and how sensitive the results are to operating environment assumptions. Thus, the benefit-cost analysis also provides information on where refinements are needed, how the field test should be designed, and the appropriate implementation strategy.

Five different scenarios were run to demonstrate the potential of EPAS. These scenarios are described in Table 1. They could be identified as follows:

Table 1

Simulation Scenarios For Benefit-Cost Analysis

Scenario Characteristics	1 Baseline	2 Poor Supply	3 Uneven Training Schedule	4 Probabilistic Soldier Choice	5 No Planning
Supply Quality	High Quality	Low Quality	High Quality	High Quality	High Quality
Training Schedule	Even	Even	Uneven	Even	Even
Soldier Choice	First Choice	First Choice	First Choice	Probabilistic Choice	First Choice
Planning Environment	Look Ahead	Look Ahead	Look Ahead	Look Ahead	No Look Ahead

1. Baseline
2. "Poor" supply
3. Uneven training schedule
4. Probabilistic soldier choice
5. No planning

The baseline scenario uses the FY 84 contract population and training seat schedule for simulation. Each candidate will select the highest-rated training seat available to him. The entire EPAS will be simulated, including the Planning Mode and the Classification Mode with its look-ahead capability. Each of the other simulations removes or alters one of these conditions to assess the sensitivity of results.

For purposes of the benefit-cost analysis it is assumed that EPAS will not affect the supply of contracts. This may not be the case for the fully operational system. Clearly, it is the intention of EPAS to increase the probability of high quality applicants signing contracts. However, to evaluate this aspect of the allocation system, it would be necessary to evaluate detailed data on the relationship of applicant preferences, Army MOS offerings, and contract signings. (Assuming the benefit-cost analysis indicates continued work in this area, the EPAS field test would provide detailed resolution of this effect.)

The EPAS benefit-cost optimization problem is structured as follows. The aggregate planning problem solved in Stage 1 is:

- MINIMIZE PERSONNEL COSTS

- SUBJECT TO:

  - Total requirements
  - Monthly requirements
  - MOS requirements
  - MOS class size
  - Gender restrictions
  - MOS quality requirements
  - DEP policy
  - MOS priorities

The individual classification problem solved in Stage 2 is:

- MAXIMIZE INDIVIDUAL PERFORMANCE

  WHERE PERFORMANCE IS A FUNCTION OF:

  - Aggregate planning goals (look ahead)
  - Predicted job performance
  - Predicted attrition
  - Difficulty of fill
  - Time to fill
  - Quality distribution

The baseline scenario evaluates the performance of EPAS in allocating the FY84 nonprior service enlistment cohort. This represents a high quality recruiting environment. Training seat supply will be the same as in FY84, and candidates will select the first offered MOS. The scenario uses the full planning capability of EPAS.

The second scenario evaluates the sensitivity of results to supply quality by using an enlistment quality mix roughly equivalent to FY81. That year represented a supply of only 40 percent high quality soldiers, versus 63 percent in the baseline. The training requirements, applicant choice, and planning environment will remain the same as before.

The third scenario uses the alternative training schedule described in figure 3. Here the summer requirements are three times the requirements for the preceding months. This is intended to test the robustness of EPAS and its capability to support a potential policy analyses of alternative training schedules.

The fourth scenario evaluates the robustness of results to individuals' preference. In other scenarios applicants were simply given the highest priority MOS. Clearly, this is unrealistic in an operational environment, where individuals are permitted choice. As shown by Figure 4, the proportion selecting high priority MOS increases as individuals' AFQT score declines. This is because candidates with high AFQT have the bargaining position and the qualifications for the lower priority MOS.

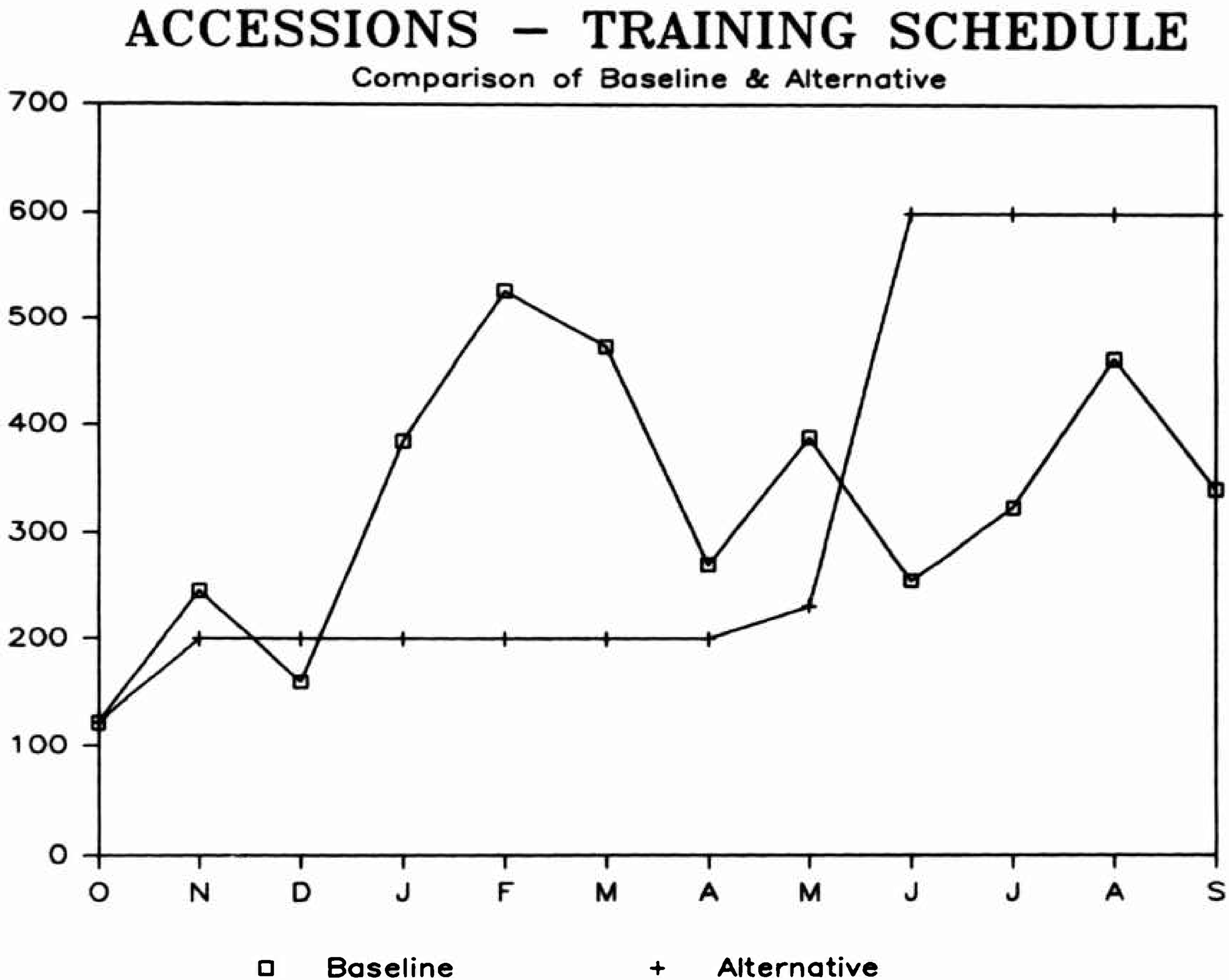

Figure 3. Accessions - Training Schedule.

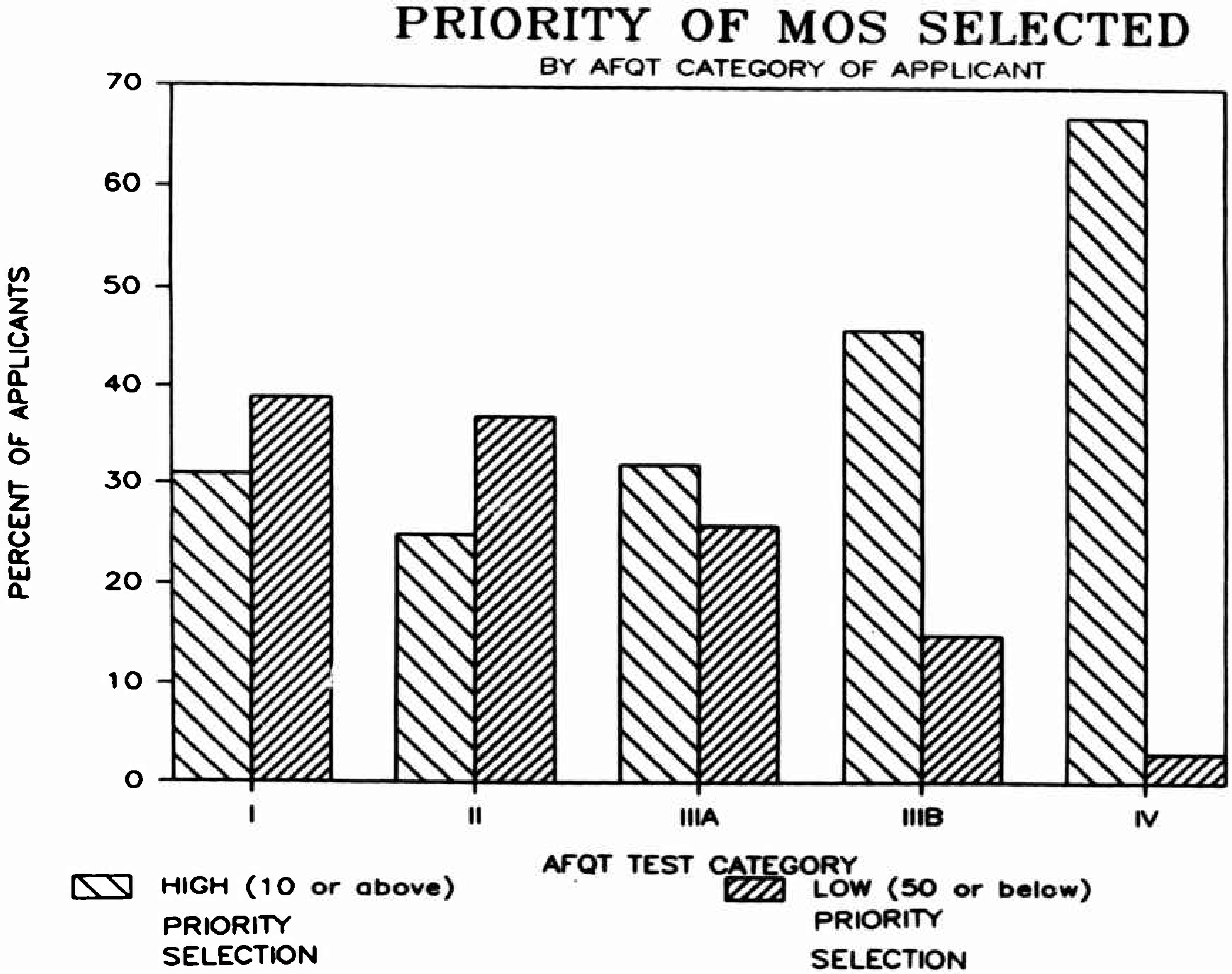

Figure 4. Priority of MOS Selected.

We attempt to model the candidates' MOS selection behavior by randomly selecting MOS from the Applicant Classification Module's ordered list. As shown in Table 2, candidates with high AFQT will be allowed a greater range on the ordered list for their random choice. Thus, the simulation will select MOS from the ordered list in proportion to AFQT category. This will examine how sensitive the assignment results are to the choice of the applicant.

Table 2

Ordered List Choices for Soldier Choice Scenario

AFQT Test Category	Ordered List Position
I	30
II	30
IIIA	20
IIIB	10
IV	5

We do not claim that our simulation of candidates' choices is totally realistic. We do not know how they would change their MOS if presented with alternative choices. However, the purpose of this simulation is to assess the sensitivity of the system's impact on this factor. The field test will address the impact of applicant choice on EPAS effectiveness along with other issues. Also, analysis of the impact of choice will indicate whether policy changes may also be warranted. Clearly, the institution of quality goals on MOS has already altered the degree to which Army preference may override the individual's.

The final scenario uses the baseline inputs for contract supply, training seats, and MOS preference, but will not use the look ahead-feature. This permits an estimate to be made of the impact of the EPAS planning function on the value of job assignments. Presumably the look-ahead capability will enhance EPAS's ability to meet personnel management goals, reduce attrition, and improve job performance. However, the Applicant Classification Module should be able to perform assignments without the look-ahead capability in the fashion of the Navy's CLASP system (Kroeker and Rafacz 1984).

HOW SIMULATION SUPPORTS THE BENEFIT-COST ANALYSIS

Here we discuss how information from the simulations described above is used to perform the benefit-cost analysis of EPAS. The kinds of indicators that were generated and how they can be interpreted are described below.

Attrition and Personnel Allocation

Person-job allocation has been shown to affect attrition in two ways:

- The characteristics of the person allocated to the specific MOS.
- The time he or she spends in the DEP for a particular MOS.

Research by Buddin (1982) and Manganaris and Schmitz (1984) has shown key demographic factors such as education and gender to affect attrition rates differentially. For example, enlistees in MOS 51K (Plumber) who do not have a high school diploma have an attrition rate 8 percent higher than those who do; for MOS 31M (Communication Expert) the difference is 40 percent. Other analyses by Baldwin and Daula (1985), and Manganaris and Schmitz (1985) provide similar findings.

A second impact of attrition that is directly related to EPAS decision variables comes from time spent in the Delayed Entry Program (DEP). Research by Baldwin and Daula (1985) and Buddin (1982) has shown that individuals spending any time in the DEP experience substantially lower in-service attrition. An analysis by Manganaris and Phillips (1985) estimated the loss probabilities and costs associated with DEP length, applicant characteristics, and MOS. Costs related to different DEP lengths were not included in the set of scenarios run for this analysis. However, one preliminary run will be reported here, while all the scenarios will soon be evaluated using differential DEP costs.

Information Supplied by the Simulations.

In addition to providing predicted performance information, the simulation must tell the benefit-cost analysis how well it will meet the Army's goals for filling MOS training requirements and quality representation requirements. Otherwise, a high objective function value could be generated by a simulation run which did a poor job of meeting Army requirements. Additionally the "fill" performance can provide information on the robustness of a simulation. That is, if environmental conditions are substantially changed, and EPAS still meets its "fill" requirement, then the EPAS' performance is robust.

EPAS provided the following indicators for the benefit-cost analysis:

- Average attrition
- Attrition cost
- Average aptitude area score
- Percent fill of MOS requirements
- Percent fill of quality requirements
- Average DEP length.

All values are based on a sample of approximately 5,000 contractees used by the simulation. For consistency, the same sample is used for all runs (with the exception of the "Low Supply" Run, which must have a different composition of enlistees).

Attrition rates were derived from Manganaris and Schmitz (1984) for the MOS clusters in the Planning Mode. The cost of attrition is directly related to the costs of training. While it may be possible to obtain some useful service from attritees, Buddin shows that the majority of attrition occurs during initial training or in the first year of service. Thus, most attritees provide little productive service time. Therefore, the average variable training and recruiting costs are used as an indicator of labor turnover costs. Presumably, in

the future these costs can be adjusted for improved predictors of attrition, improved estimates of MOS specific costs from the AMCOS project (ARI 1985), and better estimates of the economic cost of such turnover. However, while the specific results may change dramatically, the order of magnitude of the results and their implication for the benefit-cost analysis results should not change.

Job performance is a key indicator of an improved assignment system. Project A classification research will produce a new set of predictors for MOS determination. However, measures from the current ASVAB will be used at this time. For this analysis we will use the aptitude area scores as indicators of expected performance gains from improved job assignments.

The value of improved job performance has not been explicitly measured, although it is obviously an important policy concern. Nevertheless, Fernandez and Garfinkle (1985) and Schmitz and Nelson (1985) have attempted to estimate its implied value through recruiting costs. The Army expends considerable resources through recruiter effort, bonuses, educational benefits, and two year enlistment terms to attract high quality soldiers. One of the outputs of this expenditure is increased performance on job skill tests such as SQTs, which Schmitz and Nelson (1982) have shown to be a function of aptitude area scores. Thus if an improved allocation process can increase average aptitude area scores, the accessioned soldiers should show a net improvement in SQT performance. Thus it may be possible to estimate the value of this improved performance by calculating the increased recruiting costs of accessing the additional quality people needed to attain the same level of performance.

One way to value the increased performance of a given allocation is to estimate the number of quality (AFQT Category I-IIIA) contractees that would be required (replacing an equivalent number of AFQT Category IVs) to give the same increase in performance. This estimate is included in the simulation results.

One important objective of EPAS is the achievement of management policies with respect to MOS requirements, quality goals, gender restrictions, DEP length, and class size. No attempt will be made to formally estimate the value of achieving such distributional requirements. However, the performance of EPAS against these constraints will be reported. Also, various potential users of EPAS results, such as ODCSPER, USAREC, MILPERCEN, and TRADOC will be asked to comment on the importance of this kind of information for operational analysis, planning, and policy determination.

The final area of analysis is the cost of implementing EPAS. An estimate is made of the costs of operating such a system through comparison to other Army computer systems. Such factors as the update frequency, size and complexity of the computer programs, and direct computer costs were assessed through comparison to FORECAST and REQUEST data processing experience. Based upon experience with such systems a projection of EPAS operational computer costs was made.

The objective function used in the EPAS planning simulations will be a cost minimization function. Cost differentials are generated from the assignment of different supply groups to MOS and the choice of DEP length. Appendix B describes the EPAS optimization planning problem. Appendix C describes the EPAS applicant classification algorithm and the weighting schemes used in these simulations.

IV. RESULTS

This section presents the results of the EPAS simulations. In general, the results demonstrated that EPAS can be a cost-effective enhancement to Army recruiting management. The results from each simulation run are summarized in Table 3 and are discussed below.

BASELINE CASE

The Baseline case showed an attrition reduction of 5.5 percent which could save about $30M. EPAS performed much better than the system used in FY 84 as it met virtually all the MOS requirements and nearly all the quality requirements. As previously discussed, aptitude scores are not part of the objective function of the optimization but are incorporated in the scoring for the classification simulation. These improved by nearly 2 percent.

LOW QUALITY CASE

For this scenario we used a contractee sample with 40 percent quality as opposed to the FY 84 quality of about 63 percent. Therefore we must compare attrition reductions and aptitude area score improvements to these values in the sample of contractees that we used, not to the base case. The net attrition reductions and consequent dollar savings were nearly the same as in the base case. However, the average aptitude area score was improved more than in the base case. Both these measures indicate the robustness of the system. As would be expected, many of the quality requirements were not met. It is significant that even though the population has lower aptitude area scores (and thus would be expected to quality for fewer MOS) EPAS still met 99 percent of the MOS requirements.

Table 3

EPAS Simulation Results

	FY '84	BASELINE	LOW QUALITY	HIGH SUMMER TRAINING	PROB CHOICE	NO LOOK-AHEAD
ATTRITION	0.347	0.328	0.333	0.321	0.324	0.335
REDUCTION (%)		5.5	4.9	7.5	6.6	3.5
			# 0.350			
COST SAVINGS($M)		$30	$27	$41	$36	$19
AVE APTITUDE	108.0	110.1	107.9	110.2	108.9	10[illegible].6
IMPROVEMENT (%)		1.9	2.9	2.0	0.8	1.5
			# 104.9			
MOS RQMTS (%)	90	100	99	98	93	97
QUALITY RQMTS(%)	88	98	74	97	89	96

\# Attrition and average aptitude area scores are compared to original assignments of low quality contractees.

HIGH SUMMER TRAINING

This scenario tested how well EPAS could "look ahead" and bank qualified applicants for (in this case) a very high summer training load. Surprisingly, this scenario had a lower attrition than the base case. This probably indicates that, even though there was a 3-fold increase in requirements from May to June, the relative stability of month-to-month requirements allowed the optimization to better allocate assignments such that attrition was minimized. Nearly all of the quality and MOS fill requirements were met and the average aptitude area score improvement was about the same as the baseline case.

PROBABILISTIC CHOICE

This scenario showed that EPAS will be robust in the face of applicants being allowed some leeway in their choice of an MOS. The attrition reduction was actually slightly greater than in the baseline case but the average aptitude score did not improve quite as much. However the fill, both for quality and MOS requirements, was lower than desired, with most of the discrepancy occurring in the last month of the simulation. With the small sample, EPAS could not allow flexibility in MOS choice, and still fill the MOS which had a small number of total requirements and a few openings in the later months. An alternative would have been to not allow any "choices" in September. We will also "tune" the Classification Module to improve its performance under these conditions. However, we do not consider that this would be a problem with a larger sample size.

NO LOOK-AHEAD

This scenario helped assess the value of the look-ahead feature of EPAS. The Classification Module did quite well in meeting MOS and quality fill requirements. Based on this run, it would appear that the look-ahead insights from the optimization account for about 40 percent of the Baseline Scenario's attrition reduction. However, it should be noted that we do not yet have a measure to evaluate the benefits of the optimization in creating a robust quality allocation strategy.

EPAS COSTS

Table 4 presents our estimate of EPAS life cycle costs. They will support the transition of the working prototype system into an operational system. Software development will be relatively minor, followed by an operations and maintenance phase.

The values do not include "sunk" costs, such as the cost of the EPAS Contract. Nor do they include costs to maintain or operate the current systems, such as REQUEST, which are either incorporated or used as an adjunct to EPAS.

Table 4

EPAS Life-Cycle Costs (Cost in $M)

Fiscal Year (19)	88	89	90	91	92	93
ADPE Costs	.25	.2	.1	.1	.1	.1
Software Development	1.0	.5				
Operations & Maintenance		.25	.5	.5	.5	.5
Training	.1	.1	.1	.05	.05	.05
Analysis		.5	.5	.5	.5	.5
Total	1.35	1.55	1.2	1.15	1.15	1.15

The EPAS life cycle costs are quite low. Primarily this is because most of the computer code developed during the EPAS contract for the prototype system can be used in the implemented system.

V. DISCUSSION

The benefit-cost evaluation of the allocation process has shown that the prototype EPAS is likely to produce:

- Substantially reduced first-term attrition
- Increased soldier performance
- Improved accession management.

The simulations indicate that these results can be produced under a wide range of scenarios. Furthermore, the two-stage process used in EPAS increases the value of the solution more than the one-stage approach that ignores the aggregate demand and supply information. Thus, the planning system should improve observable cost and performance characteristics in addition to providing important management support.

While the analysis indicates that MOS allocation <u>can</u> be performed, additional work is necessary to determine how allocation policy <u>should</u> be performed. Both scientific research and management analysis is needed to assure the Army of a cost-effective system. Research needs to be performed on the objective for the optimization problem, the estimation of trade off parameters from existing and future data sources, the weights and structure of the classification algorithm, and the impact of applicant preference in the negotiation process. Improvements in these areas could substantially improve the value of the system.

A more fundamental issue for implementation and utilization of EPAS is establishing its compatibility with the Army's operational environment. The Army needs to be assured that the system can be implemented without creating any significant negative impact on the present allocation process, such as increased processing costs, increased qualified-but-not-enlisted rates, or unintended distributional side effects. These problems can be avoided by working with the system users and accession policy makers to achieve a successful implementation.

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APPENDIX A

Attrition Costs From the US Army
OMA & MPA Cost Factors (DCA-H-1)
Officer of the Comptroller, December 1984.

Variable Costs Associated with Attrition Turnover:

Training Costs	(B-124)		$8800
Acquisition Costs			$3750
Recruiting	(B-119)	2350	
Clothing	(B-104)	500	
Accession Travel	(B-110)	900	
Total			$12550

APPENDIX B

Optimization Problem for the Planning Mode

Supply Groups:	From FY84 contract population. Defined by AFQT, gender, and education.
MOS Groups:	Attrition Clusters.
Training Seats:	Same as FY84.
Supply Flow:	Same as FY84.
Attrition Rates:	(ATTRIT) Estimated by Manganaris and Schmitz (1984).
Attrition Costs:	(COST) From US Army OMA & MPA Cost Factors.
DEP Constraints:	Graduates & nongraduates: 1-6 months. Seniors: June-September after graduation.
Quality Goals:	Based on ODCSPER goals for FY 84.
MOS Requirements:	Based on ODCSPER goals for FY 84.
Objective:	$\text{MIN} \sum_{ij} (\text{ATTRIT}_{ij} \cdot \text{COST}) N_{ij}$
s.t.	Supply MOS Requirements Quality Goals
where	N_{ij} is the number of enlistees from Supply group i assigned to MOS cluster j

APPENDIX C

Algorithm for the Applicant Classification Module

- **PREDICTED JOB PERFORMANCE - user's choice from:**
  - Aptitude area score
  - Predicted SQT
  - Performance/worth with predicted SQT for performance.

- **1st TERM ATTRITION - ARI attrition equations.**

- **DIFFICULTY OF FILL - defined by priority:**
  - 1-3 are hard to fill
  - 4-6 are moderate
  - 7-9 are no difficulty

- **TIME TO FILL**
  - Annual demand - ramp function using ratio of class room capacity to date/total capacity to contracts to date/annual requirement.
  - Specific class - 3 step function (1 for each difficulty of fill category) generating score based on number of months left before class begins.

- **CURRENT FILL**
  - Annual - see time to fill
  - Class - full value until nominal class size reached; then half value; not eligible when max size reached.

- **AFFIRMATIVE ACTION - ramp function varying score above/below nominal value as current fill is behind or ahead of goal.**

- **QUALITY DISTRIBUTION - similar to affirmative action, but uses AFQT CAT I-IIIA goals.**

- **ELIGIBILITY REQUIREMENTS**
  - Quality goals
  - AFQT CAT IV caps
  - Aptitude area qualifying scores
  - Female exclusions
  - High school graduation
  - Others are possible such as citizenship, age, etc.

- **WEIGHTS - see next page.**

CLASSIFICATION SCORING FACTORS

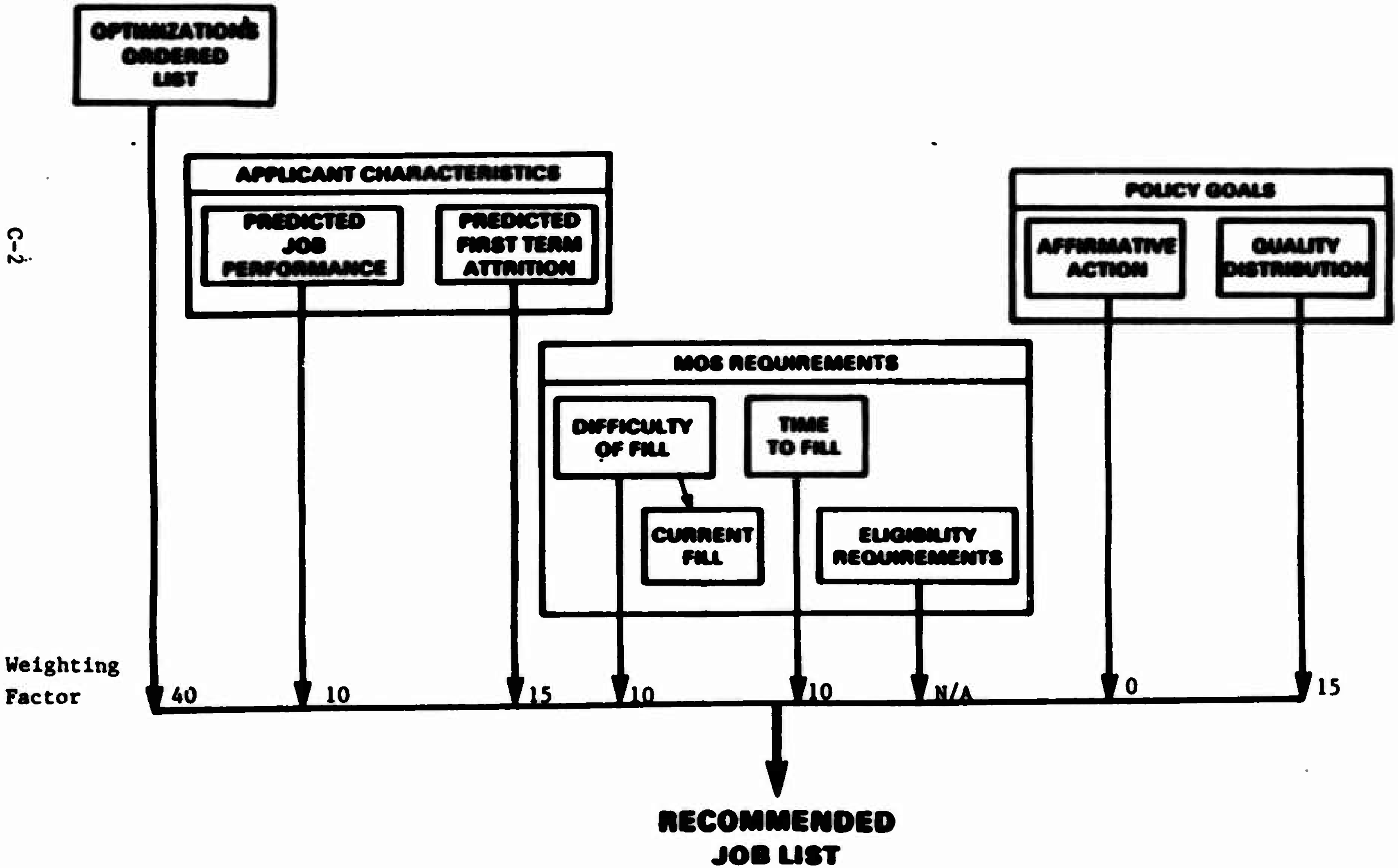

Figure C-1. Classification Scoring Factors.